UPRIGHT EXTRACTION CLEANING MACHINE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a divisional application of U.S. patent application Ser. No. 09/112,527, filed Jul. 8, 1998, now U.S. Pat. No. 6,167,587, issued Jan. 2, 2001, which claims the benefit of U.S. Provisional Application Serial No. 60/075,924, filed on Feb. 25, 1998, and U.S. Provisional Application Serial No. 60/052,021, filed on Jul. 9, 1997.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an extraction cleaning machine and, more particularly, to an upright extraction cleaning machine.

2. Description of Related Art

Upright extraction cleaning machines have been used for removing dirt from surfaces such as carpeting, upholstery, drapes and the like. The known extraction cleaning machines can be in the form of a canister-type unit as disclosed in U.S. Pat. No. 5,237,720 to Blase et al. or an upright unit as disclosed in U.S. Pat. No. 5,500,977 to McAllise et al. and U.S. Pat. No. 4,559,665 to Fitzwater.

Current upright extraction cleaning machines can be made easier to use by limiting the weight and number of components, such as fluid storage tanks, on the pivoting handle of the upright cleaning machine. Reducing the weight that a user must support as the handle is tilted rearwardly can also lower the center of gravity for the machine, which results in a better feel to the user.

Furthermore, the current extraction cleaning machines can be made easier to use and better adapted for a variety of cleaning conditions. For example, none of the current extraction cleaning machines includes an elevator responsive-to-handle position for restraining a floating roller-type agitation brush, which is automatically height adjustable in response to changes on the surface being cleaned. Another problem inherent with the known extraction cleaning machines is the difficulty of filling and emptying the fluid supply chamber and fluid recovery chamber, particularly with bladder-within-a-tank type assemblies. Further, none of the current upright extraction cleaning machines are simply convertible to a pre-spray applicator for directing cleaning solution to and agitating the surface to be cleaned without applying suction. Finally, current extraction cleaning machines do not use a the same motor to drive an agitation brush as well as an impeller. Is some cases a separate motor is used. In other cases, a turbine is used to drive the agitation brush or brushes which diminishes the suction power available to extract the dirty solution from the floor surface.

A more recent development in the extraction cleaning industry is the use of steam or hot water as a cleaning agent. The cleaning machine incorporates a boiler or other means for generating steam or hot water, which is pumped to an applicator where it is brought into contact with the surface being cleaned. Because the steam is airborne, it may be unsafe to include detergents and the like in the cleaning solution. Further, while the steam systems have the advantage of creating a temperature that effectively kills a wider range of microbes, bacteria, microorganisms, and mites, the steam systems generally suffer from poor cleaning performance. Additionally, the high power requirement for generating steam may not be sufficient with ordinary 120V power supplies for running a vacuum motor as well as the steam generator, so cleaning performance is further hindered. Also, by adding a heater to a fluid supply chamber, the user may be inconvenienced by the amount of time required to heat the contents of the supply chamber to the desired temperature. Conversely, conventional detergent cleaning systems are somewhat effective at cleaning surfaces, but could be made more effective by raising the temperature of the cleaning solution to some temperature below the boiling point. There is an optimal temperature at which cleaning performance is maximized without causing damage to carpets or setting stains. This temperature is around 150° Fahrenheit.

SUMMARY

According to the invention, a portable surface cleaning apparatus comprises a base module for movement along a surface and having a rear portion, an upright handle pivotably attached to the rear portion of the base module, a liquid dispensing system and a fluid recovery system. The liquid dispensing system comprises a liquid dispensing nozzle associated with the base module for applying liquid to a surface to be cleaned, a flexible bladder defining a fluid supply chamber for holding a supply of cleaning fluid and a fluid supply conduit fluidly connected to the fluid supply chamber and to the dispensing nozzle for supplying liquid to the dispensing nozzle. The fluid recovery system comprises a fluid tank on the base module having an recovery chamber for holding recovered fluid and enclosing the flexible bladder, a suction nozzle associated with the base, a working air conduit extending between the tank and the suction nozzle and a vacuum source in fluid communication with the tank for generating a flow of working air from the nozzle through the working air conduit and through the tank to thereby draw dirty liquid from the surface to be cleaned through the nozzle and working air conduit and into the tank.

In accordance with one embodiment of the invention, a fluid passageway is provided between the fluid supply chamber and the recovery chamber of the tank, whereby the tank is in fluid communication with the fluid supply chamber and the pressure in the flexible bladder is equalized with the pressure in the tank as the cleaning fluid is dispensed and the dirty liquid is collected in the tank. The flexible bladder preferably includes an outlet opening in the bottom portion thereof connected to the fluid supply conduit. In one embodiment, the flexible bladder extends between a bottom surface of the tank and an upper portion of the tank.

In a preferred embodiment, the fluid passageway between the fluid supply chamber and the recovery chamber of the tank comprises a filling spout disposed in an upper portion of the flexible bladder. A baffle plate is mounted within the upper portion of the tank and includes an opening. The filling spout on the flexible bladder extends through the opening in the baffle plate and is supported thereby. Preferably, the tank includes a removable lid on a top portion thereof and a filling spout is disposed between the baffle plate and the lid.

Further according to the invention, in one embodiment, the tank has an outlet opening in a bottom portion thereof and a drain plug is removably mounted in the outlet opening.

In another embodiment, a lid mounted on the tank defines an expansion chamber having an inlet opening and an outlet passage between the expansion chamber and the tank. The working air conduit is connected to the lid inlet opening so that the working air is drawn through the expansion chamber

in the lid and into the tank. A first diverter baffle in the expansion chamber reverses the direction of flow of the working air between the inlet opening and the outlet passage. A second diverter baffle in the outlet passage reverses the direction of flow of the working air between the expansion chamber and the tank. Thus, the working air flow reverses direction twice between the inlet opening of the expansion chamber and the tank. The lid is preferably removably mounted to the tank. In one embodiment, the outlet passage extends beneath the expansion chamber and includes an outlet opening and the filling spout in the flexible bladder includes an opening beneath the lid and substantially above the outlet opening in the outlet passage. Further, the filling spout is disposed between the baffle plate and the lid and the lid includes a shroud extending downwardly from the bottom surface thereof surrounding the filling spout to a point below the opening of the filling spout. Preferably, the shroud extends beneath the outlet opening of the outlet passage.

In another embodiment, the working air conduit includes a conversion valve for selectively opening and closing fluid communication between the tank and the suction nozzle. A manual actuator knob is connected to the conversion valve for movement between first and second positions and thereby selectively moving the conversion valve between open and closed positions. According to the invention, an over-center linkage mechanism is connected to the manual actual knob to bias the conversion valve to the open and closed positions. In a preferred embodiment, the over-center linkage mechanism comprises a spring-biased plunger assembly mounted to the actuator knob for movement therewith. The actuator knob is preferably mounted to the base module for rotational movement between the first and second positions and the spring-biased plunger assembly is mounted to the actuator knob for rotational movement therewith. In a preferred embodiment, the conversion valve is pivotably mounted to the base for rotational movement between the open and closed positions and the conversion valve includes an arm having a distal end extending to the plunger assembly and rotatably connected thereto. The rotational motion of the actuator knob is translated to rotational movement of the conversion valve through the arm.

In yet another embodiment, a flow indicator is mounted to the base module and has a visibility window observable to a user and the flow indicator is disposed in the fluid supply conduit and is responsive to the flow of fluid through the fluid supply conduit to visually indicate the flow of fluid through the supply conduit to the user. In a preferred embodiment, the flow indicator comprises an impeller rotatably mounted in a flow indicator housing and driven by the fluid flowing through the flow indicator.

In still another embodiment of the invention, a fluid supply conduit in the liquid dispensing system includes a pump fluidly connected to the fluid supply chamber and to the dispensing nozzle for supplying cleaning fluid to the dispensing nozzle. A pump primer is connected to the pump for priming the pump and includes a valved opening connected to the vacuum source. According to the invention, the pump primer includes a housing defining a priming chamber with an inlet opening connected to the fluid supply chamber and an outlet opening connected to an inlet for the pump. In a preferred embodiment of the invention, the valved opening is in an upper portion of the priming chamber. Further, the pump primer includes a valve chamber and a plunger chamber. The valve chamber has an inlet opening defined by the valved opening in the primer chamber and an outlet opening defining an inlet opening to the plunger chamber. The plunger chamber has an outlet opening in fluid communication with the vacuum source. A buoyant plunger is reciprocally mounted in the plunger chamber for generally vertical movement therein. A valve is mounted in the valve chamber and reciprocally movable between the inlet opening and the outlet opening thereof and connected to the plunger for movement therewith. By this structure, the valve closes the outlet opening to the valve chamber when fluid in the plunger chamber raises the plunger and the valve closes the inlet opening when fluid in the plunger chamber falls to a predetermined level. In a preferred embodiment of the invention, the valve in the valve chamber is an umbrella valve.

In a further embodiment of the invention, the surface cleaning apparatus includes a fluid supply conduit including a pump fluidly connected to the fluid supply chamber and to the dispensing nozzle for supplying cleaning fluid to the dispensing nozzle. The pump has a drive shaft for driving the pump. An agitation brush is mounted in the forward portion of the base module. A motor is mounted in the base housing and has a motor drive shaft connected to the agitation brush for rotatably driving the agitation brush. According to the invention, a first mechanical connector extends between the motor drive shaft and the pump drive shaft, whereby the motor drives both the agitation brush and the pump. In a preferred embodiment of the invention, the motor drive shaft is connected to the agitation brush through a second mechanical connector between the pump drive shaft and the agitation brush. The pump drive shaft has a mechanical step-down device connecting the drive shaft to the first mechanical connector to step down the speed of rotation of the motor shaft in the pump drive shaft. Preferably, the first and second mechanical connectors are belts, with the second connector preferably being a timing belt and the first connector preferably being a stretch belt. Typically, the stretch belt rides directly on the motor drive shaft. In a preferred embodiment of the invention, inner and outer pulleys are mounted in axially spaced relationship on the pump shaft, wherein the timing belt is reeved around the outer pulley and the stretch belt is reeved around the inner pulley. Further, there is a baffle between the inner and outer pulleys to minimize liquid transfer between the inner and outer pulleys- The inner and outer pulleys are preferably of a size to step down the speed of rotation of the motor shaft at the pump drive shaft and at the agitation brush. Further according to the invention, the base module includes a housing with an opening adjacent to the first mechanical connector and a removable door is selectively mounted to the housing to cover the opening. Preferably, the removable door includes a flange and the housing includes a groove and the flange is slidably received in the groove to at least partially support the door in the opening. The housing preferably includes a second removable door which forms a portion of the baffle between the inner and outer pulleys.

Further according to the invention, the base module includes an upper housing portion and a lower housing portion and an upright handle is pivotably mounted to the rear portion of the base module through at least one bearing for rotatable reception in the housing. According to the invention, a socket is formed between the upper and lower housing portions for rotatably receiving the bearing. Preferably, the bearing is formed integral with the lower portion of the upright handle. Desirably, the socket is formed by arcuate surfaces in mated edges of the upper and lower housing portions. The lower portion of the upright handle includes diverging arms, each including a bearing. Each bearing is formed integral with the lower portion of the

upright handle. Typically, wheels are mounted to an axle which are received within the bearings for rotationally mounting the wheels to the handle.

In accordance with another embodiment of the invention, a portable surface cleaning apparatus has a base module with a brush assembly having an agitation brush generally disposed in the front portion of the base module and a pivot arm for pivotably supporting the agitation brush relative to the base module. A first end of the pivot arm is mounted to the agitation brush for rotation of the agitation brush with respect to the pivot arm and a second end of the pivot arm is pivotably mounted to the base module, whereby the brush assembly is free-floating to adjust to different surface heights. According to the invention, an elevator assembly is reciprocally mounted to the base module and movable in response to movement of the upright handle from an operative position to the upright position. The elevator assembly includes an arm disposed at one end adjacent the pivot arm and having a lifting surface for upwardly pivoting the pivot arm and a second end extending toward the handle and having a contacting surface for sliding along the outer surface of the lower portion of the handle. Movement of the arm toward the front portion of the base module by pivoting the upright handle to the storage position is translated into movement of the agitation brush away from the surface to be cleaned. Preferably, a spring biases the arm toward the handle.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the drawings wherein:

FIG. **1** is a perspective view of the extraction cleaning machine according to the invention;

FIG. **2** is an exploded view of a base module of the extraction cleaning machine shown in FIG. **1**;

FIG. **3** is an exploded view of a base module and tank assembly of the extraction cleaning machine of FIG. **1**;

FIG. **4** is an exploded view of a handle assembly and portions of the base module for the extraction cleaning machine of FIG. **1**;

FIG. **5** is a partial sectional side view of the foot module of the extraction cleaning machine of FIG. **1**;

FIG. **5A** is an exploded view of a floating brush assembly for the extraction cleaning machine of FIG. **1**;

FIG. **5B** is a perspective view of an alternative brush assembly for the extraction cleaning machine of FIG. **1**;

FIG. **6** is a partial sectional side view of the extraction cleaning machine of FIG. **1** with the handle assembly in a tilted position;

FIG. **7** is a side sectional view of the pump and pump priming assembly of the extraction cleaning machine of FIG. **1** with a plunger in a first position;

FIG. **8** is a side sectional view of the pump and pump priming assembly of the extraction cleaning machine of FIG. I with a plunger in a second position;

FIG. **9** is a partial perspective view of the belt access door assembly of the extraction cleaning machine of FIG. **1**;

FIG. **10** is a partial sectional view of the auto-mix valve of the extraction cleaning machine of FIG. **1** with a valve stem in a first position;

FIG. **11** is a partial view of the auto-mix valve of the extraction cleaning machine of FIG. **1** with a valve stem in a second position;

FIG. **12** is a partial side sectional view of a diverter valve with the valve plate shown in a first position and in phantom for a second position for the extraction cleaning machine of FIG. **1**;

FIG. **13** is a partial side view of the valve assembly of FIG. **12** with the valve plate in the second position;

FIG. **14** is a sectional view of the air/water separator lid along line **14—14** of FIG. **3**;

FIG. **14A** is a partial side view of a closure plate in three positions relative an air exit from the air/water separator lid of FIGS. **13** and **14**;

FIG. **14B** is a partial sectional view taken along lines **14B—14B** of FIG. **14**;

FIG. **15** is a sectional view of the air/water separator lid along line **15—15** of FIG. **14**;

FIG. **16** is a partial sectional view of the tank assembly and handle assembly of the extraction cleaning machine shown in FIG. **1**;

FIG. **17** is a fluid flow diagram for the extraction cleaning machine of FIG. **1**;

FIG. **18** is an exploded view of the in-line heater of the extraction cleaning machine of FIG. **1**;

FIG. **19** is a top view of the fluid flow indicator of the extraction cleaning machine of FIG. **1**;

FIG. **20** is a side sectional view of the fluid flow indicator of FIG. **19**;

FIG. **21** is a bottom perspective view of a drain plug of the base module and tank assembly of FIG. **3**; and

FIG. **22** is a top perspective view of the drain plug of the base module and tank assembly of FIG. **3** and illustrated in FIG. **22**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and to FIG. **1** in particular, an upright extraction cleaning machine **12** according to the invention is shown. The machine **12** is a portable surface cleaning apparatus including a base module **14** adapted to roll across a surface to be cleaned and an upright handle assembly **16** pivotably mounted to a rear portion of the base module **14**.

As best shown in FIGS. **1–3**, the base module **14** includes a lower housing portion **15** and an upper housing portion **17**, which together define an interior for housing components and a well **730** for receiving a tank assembly **50**. Further, a well **732** in the upper housing portion **17** receives a detergent supply tank **870**, as best shown in FIG. **3**. The upper housing portion **17** receives a transparent facing **19** for defining a first working air conduit **704** and a suction nozzle **34**, which is disposed at a front portion of the base module **14** adjacent the surface being cleaned for recovering fluid therefrom. The handle assembly **16** has a closed loop grip **18** provided at the uppermost portion thereof and a combination hose and cord wrap **20** that is adapted to support an accessory hose **22** and a electrical cord (not shown) when either is not in use. A latch assembly **21** is pivotably mounted to the rear portion of the base module **14** adjacent the rotational union of the handle assembly **16** therewith for releasably locking the handle assembly **16** in its upright position.

As shown in FIG. **2**, the base module **14** houses a drive motor **196** that is connected to a source of electricity by the electrical cord. A motor compartment **500** within the base module **14** is a clamshell-shaped housing for holding a motor assembly in place and preventing rotation thereof The clamshell motor compartment **500** includes an upper half **502** and a lower half **504**. The upper half **502** is removable from the lower half **504**, which is integral to the extraction cleaner base module **14**. Thus, a bottom wall of the lower

half 504 is the bottom surface of the extraction cleaner base module 14. An arm 651 extends upwardly from the motor housing 500 in the base module 14 to support the flow indicator 650, which is mounted to an upper end thereof. An opening 653 in the upper housing portion 17 receives the flow indicator 650 when that portion is mounted to the lower housing portion 15.

The motor compartment 500 includes a large circular impeller fan housing 510 and a smaller motor housing 512, further having a generally T-shaped cross section. The impeller fan housing 510 surrounds an inner housing 41 defining a vacuum source 40, which is created preferably by an impeller (not shown) disposed within the housing 41. The housing 41 includes a large aperture 516 for mounting a vacuum intake duct 530, which is sealed to the aperture 516 by a gasket 520. The vacuum intake duct 530 connects the vacuum source 40 to an air/water separation chamber 750 (shown in FIGS. 3, 14, 14A, 14B and 15) in a lid 700 on the tank assembly 50, as well as the suction nozzle 34 on the front portion of the base module 14 and a suction nozzle (not shown) on a distal end of the accessory hose 22. The smaller end 512 includes a small aperture 524 for receiving therethrough a motor drive shaft 198. A stretch belt 204 is received on the motor drive shaft 198 outside of the clamshell motor compartment 500. Further, an upper surface 520 of the motor compartment 500 supports and secures an accessory hose intake duct 540 partially defining a second working air conduit 706 (as shown best in FIGS. 12–14), which connects the suction nozzle on the distal end of the accessory hose 22 to the vacuum source 40.

The drive shaft 198 of the drive motor 196 is connected to an interim drive shaft 200 of a solution pump 202 by the stretch belt 204, which in turn, is connected to a rotatably mounted agitation brush 206 by a timing belt 208, as best illustrated in FIGS. 5 and 6. On the opposite side of the motor 196, the motor drive shaft 198 supports the impeller (not shown) within the impeller housing 41, which provides the vacuum source 40 and is mounted inside the housing 510 of the motor compartment 500. With this configuration, a single drive motor 196 is adapted to provide driving force for the impeller, the solution pump 202, and the agitation brush 206.

As best seen in FIGS. 2, 5, 5A, and 6, the rotatably mounted agitation brush 206 is adapted for floor-responsive adjustment by a floating brush assembly 400 mounted within an agitation brush housing 26 disposed within a forward portion of the base module 14. The floating movement of the agitation brush 206 is a horizontally oriented arcuate path for reciprocation toward and outward of the agitation brush housing 26. Ends 452 of an agitation brush shaft 206 are received in bearings 454, which in turn, are press fit into inwardly extending bosses 456 to provide a pair of opposed articulating arm members 458. Alternatively, stub shafts (not shown) can extend from the arm members 458 and the ends 452 can be replaced with bearings similar to 454 for rotational installation of the brush 206 on the arm members 458.

Each arm member 458 comprises a back plate 460 with a pivot pin 462 provided at the rear of the plate 460. In addition, a laterally extending belt guard 466 is preferably integrally formed with the articulating arm 458. The belt guard 466, which extends laterally inwardly enough to cover the timing belt 208, minimizes the lodging of threads and other foreign material in the timing belt 208 and protects the carpet or other surface positioned below the base assembly 14 from the rotating belt 208.

As best shown in FIGS. 5–6, 9, the timing belt 208 is reeved through a pulley 216 mounted at one end of the brush 206 and a pulley 222 on the interim drive shaft 200 of the pump 202, which includes a separate pulley 220 through which is reeved the stretch belt 204, which, in turn, extends around the drive shaft 198 of the motor 196. As best shown in FIGS. 7 and 9, the radius of the pulley 220 is larger than the radius of the pulley 222. Further, the pulley 220 has a convex cross section of its periphery, whereby it is adapted to receive the smooth stretch belt 204, while the pulley 222 has a toothed perimeter adapted for registration with the teeth in the timing belt 208.

The pivot pins 462 of the arm member 458 are rotatably supported secured in a bearing (not shown) mount integrally formed with an internal wall of the agitation brush housing 26. Further, the pivot pins 462 are held in the bearing by a support 478 on the non-belt side of the base module 14 and the an arm 258 of the second belt access door 252 on the belt side of the base module, as best shown in FIG. 5A. Both the arm 258 and support 478 are secured to the agitation brush housing 26 by a conventional fastener (not shown) inserted through an aperture in each part. The arm members 458 are preferably limited in their downward movement relative to the agitation brush housing 26 by the length of the timing belt 208 as well as the engagement of the brush guards 466 with the arm 258 and the support 478. As the floating brush assembly 400 extends further and further downwardly, the belt 208 will stretch and resist further downward movement. Eventually, the brush guards 466 on each arm 458 will contact respectively the arm 258 and the support 478, which prevents any further downward movement.

With this floating agitation brush assembly 400, the cleaning machine 12 according to the invention can almost instantaneously adapt to varying carpet naps or other inconsistencies on the surface being cleaned. The arm members 458 also allow the rotating brush 206 to drop below the normal floor plane, as shown in FIG. 6, to, for example, provide contact with a bare floor.

As an alternative to the floating, rotatably mounted agitation brush 206, a floating strip agitation brush 224 could be incorporated into the cleaning machine 12, as seen in FIG. 5B. In this embodiment, the strip brush 224 comprises a linear brush portion 492 with bristles 494 extending downwardly therefrom, and a pair of integrally molded arms 496 having pivot pins 502, which can mount to the arm members 458 in place of the pivot pins 462 supporting the agitation brush 206. With this structure, the strip brush 224 can move vertically in response to changes to the carpet nap or other inconsistencies in the floor being cleaned.

As shown in FIGS. 2, 5 and 6, an elevator assembly 410 comprises a central support member 412 having at one end an L-shaped actuating arm 418, and at another end, the ramped surface 414 on a forward arm 404 opposed by a guide 416. Between the guide 416 and the ramped surface 414 is mounted a spring assembly 406, which biases the assembly 410 rearward toward the handle assembly 16. The spring assembly 406 includes a spring 436; a stop 426, which is attached to the base module 14 and through which the forward arm 404 travels; and a flange 428, which is integral with the forward arm 404. The spring 436 is held between the flange 428 and stop 426, and biases the assembly 410 rearward relative the stop 426 through force on the flange 428.

The arm 418 extends from within the base module 14 where it is mounted, through an aperture 402, towards the handle assembly 16. The actuating arm 418 is forced horizontally forward when the rotatably mounted handle 16 on the base module 14 is put in the upright position, which

forces an upper portion **422** of the actuating arm **418** in a horizontal and forward direction. More specifically, as shown in FIG. **5**, a curved surface **424** on the handle assembly **16** strikes a rounded distal end **420** of the L-shaped actuating arm **418** when the handle assembly **16** is put in its storage or non-use position. When the handle assembly **16** is pivoted rearwardly for use, as shown in FIG. **6**, the curved surface **424** shifts rearwardly and the springbiased elevator assembly **410** follows, with end **420** riding the curved surface **424**, until the elevator assembly **410** reaches a rearward, rest position.

Thus, forward movement of the actuating arm **418** forces the support member **410** and ramped surface **414** forward, wherein the ramped surface **414** contacts the underside of the brush guards **466** on each arm **458**, thereby raising the floating brush assembly **400** as the elevator assembly **410** moves from a rearward position to a forward position in the base module **14**. That is, as the ramped surface **414** moves towards the front of the base module **14**, the agitation brush assembly **400** slowly rises as the brush guards **466** ride the ramped surfaces **414**. Such a construction eliminates the need for a manual arm for lowering and raising the agitation brush assembly **400** for storage or use of the accessory hose **22**, thereby eliminating risks of damage to the brush assembly and protecting the carpet from the agitation brush assembly **400** resting thereon. When the handle **16** is moved to the in-use position, the spring assembly biases the elevator assembly to its normal, rearward position.

As seen best in FIGS. **1** and **4**, the base module **14** is supported at the rear portion thereof by a pair of opposed rear wheels **552**. The handle assembly **16** includes a U-shaped lower portion **560** having opposed aims **562** and **564** including cylindrical bearings **578** for mounting the handle assembly **16** to the base module **14** and supporting axles **554** on a common axis for rotatably mounting the wheels **552** to the extraction cleaner base module **14**. More particularly, the handle assembly **16** tapers from its wide, lower portion **560** to a thinner handle portion **570**, having a thin handgrip portion **572**, including the closed loop grip **18** at its uppermost end, by which the user moves the extraction cleaner. The bearing **578** include a central circumferential groove **576** for receiving arcuate portions **588, 589** of the base module **14** whereby rotation of the handle assembly **16** is facilitated.

The handle assembly **16** further comprises a front portion **580** and a rear portion **582** defining a substantially hollow interior supported by multiple ribs **558**. Mounts **584**, disposed radially on the interior of the front and rear portions **580** and **582** support an in-line heater **54**, as will be described in detail below. The substantially flat front portion **580** is secured to the mated rear portion **582** by conventional fasteners, such as screws. The rear portion **582** further includes the combined accessory hose and electrical cord mount **20**.

Returning to the lower portion **560**, the arms **562, 564** comprise portions of both the front portion **580** and the rear portion **582**. When the assembly **16** is secured together, these arms **562, 564** pivot about the bearing **578** integrally formed with the arms **562, 564**. The bearings **578**, in turn, receive axles **554**, on each side, respectively, for mounting wheels **552**. The axles **554** extend through the wheels **552**, apertures **586** through the rear portion **582** of the lower arms **562, 564**, and the bearings **578** integrally formed with the arms **562, 564**. The axles **554, 556** are secured by large diameter axle mounting clips **594**, disposed, when installed, adjacent the bearings **578** and within the base module **14**. A side edge **598** of the extraction cleaner base module **14** includes an arcuate surface **588** to accommodate the handle bearings **578** secured on inside portions of each arm **562, 564** of the rear portion **582**.

Once the handle assembly **16** is mounted to each base module **14**, with the axles **554** secured by the mounting clips **594**, the extraction cleaner upper housing portion **17** is secured to the lower housing portion **15**. The upper housing portion **17** also has an arcuate surface **589** formed in a side thereof for accommodating and securing the integral bearings **578** of the arms **562, 564**. More specifically, the arcuate surfaces **588, 589** of the side walls of the housings **15, 17** are received in the central circumferential groove **576** formed in the circumference of each integral bearing **578**. Thus, when the base module **14** is formed of the housings **15, 17**, the bearings **578** of the arms **562** are secured therebetween such that they can only rotate between an upright, stored position and an in-use position and the wheels are mounted to axles **554,556** received through apertures in the bearings **578** and secured by mounting clips **594**.

Theconcentric wheel axle and handle pivot transfers all the force on the handle assembly **16** to the wheels **552** to keep downward force on the suction nozzle **34** constant. Further, the tank assembly **50**, as shown in FIG. **3**, center of gravity is close to the wheel center so that changing tank volume does not alter the downward force on the suction nozzle **34** and allows the weight of the tank assembly **50** to be carried on the wheels **552** fairly evenly. Also, the handle assembly **16** supports very little weight and therefore keeps the weight that the user feels through the handle assembly **16** to a minimum. This creates an upright extraction cleaning machine **12** that is easy to use and less tiring for the operator.

The handle assembly **16** is releasably locked against rotation from its upright position by a latch assembly **21**, which is pivotably mounted to the rear portion of the base module **14** adjacent the rotational union of lower leg **564**. The latch assembly **21** includes an upright lower portion which is pivotally mounted to the base module **14** at a rear corner thereof and an upper portion which extends upwardly and rearwardly of the lower portion. A molded-in spring arm extends rearwardly from the lower portion of the latch assembly **21** and bears against a rear portion of the base module **14** to bias the lower portion forwardly and against the rear portion of the lower leg **564**. The upper end of the lower portion of the latch assembly **21** forms a horizontal latching surface which bears against the rear portion of the lower leg **564** and engages projections thereon to lock the handle in the upright position in a conventional fashion. Thus, as the handle assembly **16** is pivoted upright, the rear portion of the lower leg **564** rides along the horizontal latching surface until the edge catches the projection on the rear portion of the lower leg **564**, at which point the handle assembly **16** is locked upwardly. To release the latch assembly **21**, the user pushes the step downwardly and against the bias of the molded-in spring to release the horizontal latching surface from the projection. The latching mechanism is conventional and forms no part of the invention of this application- Any conventional latching mechanism can be used with the handle and base module in the invention.

The tank assembly **50** is removably supported on the rear of the base module **14**. An air/water separator lid **700** seals the top of the tank assembly **50**, which includes a valve mechanism **80** on a bottom portion for controlling the flow of cleaning solution fluid from the fluid supply chamber **49**. The base module **14** includes a valve seat **88** complementary to the valve mechanism **80**, and the bottom portion of the tank assembly **50** and the valve seat **88** are substantially complementary to one another so that the upwardly extend-

ing valve seat **88** is substantially surrounded by and received in the bottom of the tank assembly, as will be described further below.

The lid **700** is secured to the tank assembly **50** by a rotatable handle **790**, as best shown in FIG. **16**, which can be moved between a storage position, in which the tank **50** is sealed by the lid **700** and the handle **790** is disposed rearwardly horizontal (as shown in solid lines); a transport position, in which the tank **50** is sealed and the handle **790** extends vertically upward (shown in phantom lines) for ease in carrying by the user; and a service position, in which the lid **700** can be removed from the tank assembly **50** and the handle **790** is disposed forwardly at an acute angle relative the lid (shown in dashed lines). The U-shaped tank handle **790** rotates about a pivot **792** projecting from a side of the lid **700**. The pivot **792** is received in a bushing **794** disposed centrally in a circular mounting portion **796** at the ends of the handle **790**. An arcuate wall **798** extending transversely from the mounting portion **796**, integral therewith, and having an opening **788** surrounds the bushing **794**. When the handle **790** is rotated about the pivot on the lid, an inside surface **784** of the wall **798** engages a tab **786** extending transversely from an upper lip **782** of the tank assembly **50** for locking the lid **700** to the tank assembly. The surface **784** of the wall **798** engages the tab **786** when the handle **790** is in either the storage or transport position. When in the service position, the tab **786** is aligned with the opening **788** in the wall **798**, whereupon the lid **700** can be removed from the tank assembly **50**.

As best shown in FIGS. **3**, **14**, **15**, a flexible bladder **120**, which is used as a clean water reservoir, is mounted inside a rigid tank assembly **50**. Thus, the tank assembly **50** is divided into two fluid chambers by the bladder **120**: a fluid supply chamber **49**, comprising the interior of the bladder **120**, and a fluid recovery chamber **48**, comprising the volume between the flexible bladder **120** and the rigid walls of the tank housing **46**. The bladder **120** is molded from a pliable thermoplastic material and is collapsible when empty to accommodate recovered fluid in the volume between the bladder **120** and the tank housing **46**. Initially, the bladder **120** is full of water or cleaning solution and occupies the vast majority of the volume within the tank housing **46**. As the user sprays the cleaning solution onto the surface to be cleaned, the volume of fluid in the bladder **120** is reduced corresponding to the volume of solution sprayed on the surface. During suction, recovered dirt and water are received in the tank housing **46** in the volume between the bladder **120** and the tank housing **46**. The volume available in the bladder **120** due to application of the cleaning solution is made available to recovered fluid by the pressure of the recovered fluid collapsing the bladder **120**, thereby forcing air out of the bladder **120**. Because recovery of the used cleaning solution is always less than **100%** of the solution applied, there will always be ample room inside the tank housing **46** once the cleaning solution has been applied to the surface.

The bladder **120** is disposed within the tank assembly **50** between a bottom surface **860** of the rigid tank housing **46** and a snap-in baffle plate **800**, which will be explained in further detail below. An aperture **824** in the baffle plate **800** has a diameter approximately matching that of a small diameter end **125** of a funnel-shaped filling spout **124** of the bladder **120**. Further, an upstanding collar **828** surrounds the aperture **824**. A cylindrical shroud **770**, as best shown in FIG. **17**, is mounted on the inside of the air/water separator lid **700** and extends downwardly therefrom to capture the filling spout **124**. Thus, the increasing diameter outside surface of the funnel-shaped filling spout **124** is retained in the aperture **824** and supported by the collar **828**, thereby holding the flexible bladder **120** in an upright position in the tank housing **46** between the bottom surface **860** and the baffle plate **800** therein. As space between the upstanding collar **828** and the downwardly extending shroud **770** defines a fluid passageway between the fluid supply chamber **49** and the recovery chamber **48**, whereby the fluid supply chamber **49** and the recovery chamber **48** maintain the same pressure, negative or otherwise.

The flexible bladder **120** includes an outlet **130** disposed in a lower corner of the flexible bladder **120**. The outlet **130** is mated with an outlet aperture **862**, as best viewed in FIG. **16**, in the bottom surface **860** of the rigid outer shell for supplying fluid to a fluid application system **950** and securing the bladder **120** to the rigid bottom surface **860** of the tank housing **46**.

The funnel-shaped filling spout **124** of the bladder **120** facilitates filling the bladder **120** and equalizing air pressure between the fluid supply chamber **49** and recovery chamber **48**. The filling spout **124** is always open, so as to vent air from the bladder **120** as it collapses in volume and the usable volume within the rigid outer walls of the tank housing **46** expands in volume. Further, the open filling spout **124** ensures that both chambers **48**, **49** are at substantially the same atmospheric pressure, which is preferably negative relative to standard atmospheric pressure because of the communication of the vacuum source **40** to the tank assembly **50** via the air/water separator lid **700**, as will be explained further below. The volume of the bladder **120** is preferably one gallon.

As best shown in FIG. **17**, the valve mechanism **80** is provided within the outlet aperture **862** through the bottom surface **860** of the tank housing **46** and the aligned outlet **130** in the bladder **120** for controlling the flow of cleaning solution fluid from the fluid supply chamber **49**. The valve mechanism **80** comprises a valve member (not shown) mounted within the aligned aperture **862** and outlet **130**, which together are selectively covered by the valve member to enable or prevent the flow of fluid to the fluid application system **950**.

The base module **14** includes a valve seat **88**, shown best in FIG. **17**, that has a fluid reservoir **90** adapted to receive fluid through the fluid aperture **862** and conduct this fluid to one end of the conduit **140**, the other end being mounted to a clean water inlet **332** of a mixing valve assembly **310**. The bottom wall **860** of the tank housing **46** and the valve seat **88** are substantially complementary to one another so that the upwardly extending valve seat **88** is substantially surrounded by and received in the bottom wall **860**. A projection **94** is provided in the fluid reservoir **90** and is adapted to contact a head of a shaft of the valve member (not shown). A spring received on the shaft of the valve member is adapted to bias the valve member into the closed position thereby preventing the flow of fluid through the fluid apertures. When the tank housing **46** is seated on the base module **14**, the head of the valve member contacts the projection **94** and deflects the valve upwardly thereby permitting the flow of fluid around the valve, through the fluid apertures into the fluid reservoir **90** of the valve seat **88**, and to the fluid application system **950**. A gasket **81** seals the junction between the valve mechanism **80** and the seat **88**. When the tank housing **46** is removed from the base module **14**, the projection **94** is removed from contact with the head **96** of valve member. Therefore, the spring biases the valve downwardly into the closed position thereby preventing the flow of fluid through the fluid aperture **862** to the fluid application system **950**.

The fluid application system 950 conducts fluid from the fluid supply chamber 49 to fluid dispensing nozzles 100, which are mounted in the brush housing 26 of the base module 14, and a fluid dispensing nozzle (not shown), which is mounted on an accessory cleaning tool (not shown), as best illustrated in FIG. 17. From the fluid supply chamber 49, clean water is conducted through conduit 140 to an inlet 332 to the mixing valve assembly 310, which also includes a detergent inlet 336 that is fluidly connected to a detergent supply tank 870 by a conduit 314. Mixed detergent and clean water form a solution that exits the mixing valve assembly 310 via an outlet 340, which is fluidly connected by a conduit 142 to a pump priming system 280 disposed adjacent the pump 202. An inlet port 282 for the pump priming system 280 is connected to the conduit 142, and pressurized fluid is expelled from the pump 202 through a pump outlet port 283, which is fluidly connected via a conduit 146 to a T-connector 150. The T-connector 150 supplies pressurized fluid to both the accessory tool (not shown) and the heater 54 via conduits 148, 138, respectively. The conduit 148 includes a grip valve 132 by which the user can manually displace a valve member, thereby enabling the flow of non-heated, pressurized fluid to the spray tip on the accessory tool.

The conduit 138 includes a trigger valve 134 having a displaceable valve member actuable by a trigger assembly 430, as best shown in FIG. 4, for selectively supplying the in-line heater 54 with pressurized cleaning solution. The trigger assembly 430 includes a switch 432 mounted conveniently within the closed loop grip 18 of the upright handle assembly 16, through which the user can depress the switch for actuating a manual link 434 for displacing the valve member in the trigger valve 134, thereby allowing fluid to flow to the inlet port 72 of the in-line heater 54.

Heated while passing through the heater 54, the fluid exits the in-line heater 54 via an outlet port 74, which is fluidly connected via a conduit 136 to an inlet 652 for a flow indicator 650. An outlet 654 for the flow indicator is fluidly connected to a T-connector 156 via a conduit 134. The T-connector 156 supplies fluid dispensing nozzles 100, which are mounted in the brush housing 26 of the base module 14, and supplied with heating cleaning solution via conduits 126, 128.

A detergent supply tank 870, as best illustrated in FIG. 3, is received within a well formed in the upper housing 19 of the base module 14. The supply tank 870 includes a top surface 872 shaped complimentary to the exterior of the upper housing 17. A bottom surface 874 of the supply tank 870, as best shown in FIG. 17, includes an aperture 876 surrounded by a threaded spout 878, which receives a mated threaded cap 880 having a valve mechanism 882 therethrough. The valve mechanism 882 will not be described here as its structure and function mimics that valve mechanism 80 described above for the tank assembly 50, as it too seats on a projection 94 in a valve seat 318 for displacing the valve mechanism 882. The valve seat 318 of the mixing valve assembly 310 includes a fluid reservoir 320 for receiving and conducting fluid to one end of an L-shaped conduit 314, the other end being mounted to a detergent inlet 336 of the mixing valve assembly 310. The threaded cap 880 also includes an air return conduit 890 mounted therethrough for equalizing the pressure inside the detergent supply tank 870 with the outside atmosphere.

The mixing valve assembly 310 is positioned intermediate the tank assembly 50 and the solution pump 202. Preferably, the mixing valve 310 is a variable mixing valve to accommodate differing mixtures of detergent and clean water. As seen in FIGS. 10, 11 and 17, the variable mixing valve 310 comprises a valve body 330 having a clean water inlet 332 that is fluidly connected to the fluid supply chamber 49 and a detergent inlet 336 that is fluidly connected to a detergent supply tank 870 by the valve seat 318 and, via the fluid reservoir 320, the L-shaped conduit 314. The mixed solution outlet 340 is also formed on the valve body 330 and is adapted to conduct the clean water and detergent mixture, i.e., the cleaning solution, from the mixing valve 310 to a fluidly connected pump priming system 280 adjacent the inlet of the pump 202.

The valve assembly 310 includes an end cap 344 mounting a coaxial plunger 350 in a central body portion 346. The end cap 344 partially receives a thread 372 of a knob 374 such that the plunger 350 can be raised or lowered in the valve body 346 when the knob 374 is turned.

The plunger 350 includes an annular groove 356 formed in a distal end 276 thereof. The groove 356 is received within an O-ring 358. The distal end 276 and O-ring 358 are adapted to create a fluid seal inside the circular valve body 346 when the plunger 50 is in its lowermost portion, as shown in FIG. 11, and define a mixing chamber 360 when the plunger 350 is raised from its lowermost position, as shown in FIG. 10.

The distal end 276 of the plunger 350 further includes a tapered groove 364, which is tapered so that the groove has a greater cross-sectional area immediately adjacent the head end 276 than it does a distance spaced upwardly therefrom- The tapered groove is positioned in the detergent inlet 336 opening to control the flow of detergent therethrough. That is, the tapered groove 364 accommodates varying flow rates of detergent from the detergent supply 870, through the conduit 318, and through the detergent inlet 336 into the valve body 346. The lower the plunger 350 is seated in the inlet 336, the less the area of exposure of the tapered groove 364 in the valve body 346, thereby limiting the flow of detergent thereto.

The control knob 374 is mounted on an outside wall of the upper housing of the extraction cleaner for controlling the water to detergent ratio in the cleaning solution delivered to the fluid application system 950. The control knob 374 is mounted adjacent the end cap 344 and includes a thread 372 that is received in a groove 380 of the end cap 344, so that turning the knob 374 lowers or raises the plunger 350 in the valve body 346. In a first position shown in FIG. 10, with the plunger 350 extended upwardly from the valve body 346, the maximum cross-sectional area of the tapered groove 364 is exposed to define an inlet aperture 382 into the valve body 346- Therefore, the maximum amount of detergent will be drawn into the valve body 346 to mix with clean water supplied via inlet 332, and ultimately discharged to the pump assembly 280 and fluid dispensing nozzles 100. The other extreme position of the plunger 350 lowers the tapered groove 364 from the mixing chamber 360 completely so if there is no aperture 382 and thus no fluid flow communication between the detergent inlet 336 and the valve body 346. Therefore, only water will be directed to the pump assembly 280 and spray tips.

As should be evident, rotation of the threaded knob 374 will provide an infinite number of detergent-to-water mixing ratios between the two extremes described above. In the preferred embodiment, however, the housing adjacent the knob 374 is marked with three concentration indicators: The first indicator is a water only or"rinse" position; second, a maximum detergent-to-water mixing ratio where the tapered groove 364 is fully exposed in the valve body 346; or third,

a standard mixing ratio approximately half way between the extremes described previously. Of course, any variation of the indicated concentration positions can be employed by simply rotating the knob **374** to a position between any two indicated positions. The extreme positions are defined by the shape of the length of the thread **372**, which includes opposite ends defining a pair of extreme positions for limiting the rotation of the knob **374** relative the cap **344**.

In use, the knob **374** is intended to be positioned at the standard mixing ratio position for the vast majority of cleaning operations. When a high-traffic or heavily stained area is encountered, the knob **374** can be rotated to the maximum detergent position. If a clean-water rinsing operation is desired, then the knob **374** can be rotated to the water only position.

As best illustrated in FIG. **17**, the mix of detergent and water is delivered via conduit **142** to the inlet port **282** for the pump priming system **280**, which is disposed adjacent an inlet nose **288** of the pump **202**. Thus, in operation, the drive motor **196** is activated, thereby imparting rotation through the drive shaft **198** to the interim drive shaft **200**, and the pump **202** is primed, as will be explained below. Rotation of the interim drive shaft **200** causes the pump **202** to pressurize the fluid received from the fluid supply chamber **49**, via the mixing valve assembly **310** and priming assembly **280**. Further, rotation of the interim drive shaft **200** causes the agitation brush **206** to rotate. Pressurized fluid flowing from a pump outlet port **283** is conducted to the in-line heater **54**, a flow indicator **650**, and then a plurality of conventional fluid dispensing nozzles **100** provided near the front of the base module **14** adjacent the agitation brush **206**. The pressurized cleaning solution sprays down onto the surface to be cleaned in a fan-shaped pattern extending substantially the entire width of the base module **14**. A fluid outlet port **74** of the in-line heater **54** is also fluidly connected to a conduit **144**, which is integrated into the accessory hose **22**. Fluid flows through the conduit **144** to the accessory hose cleaning tool (not shown) provided at the terminal end of the hose **22**. With this configuration, pressurized cleaning solution is available on demand for both the accessory cleaning tool and the fluid dispensing nozzles **100**.

Referring to FIGS. **2**, **5** and **6**, the drive shaft **198** of the drive motor **196** is interconnected to the interim drive shaft **200** of the centrifugal solution pump **202** by the stretch belt **204**, which allows dry, high speed operation and operates as a clutch during brush roll-jam conditions. The interim pump shaft **200** is interconnected to the rotatably mounted agitation brush **206** by the timing belt **208**, which allows a slower, high torque wet operation.

The interim pump drive shaft **200** functions as an interim drive providing a step down from the drive shaft **198** to the stretch belt **204** and the timing belt **208** to the agitation brush **206**. Because of the step down structure, the drive motor **196** can be a high efficiency, high speed motor (30,000 plus rpm), which is stepped down at the interim drive pump shaft (approximately 12,000 rpm), and further stepped down at the agitation brush **206** (approximately 3,500 rpm).

The pump shaft **200** includes the pair of coaxial spaced-apart pulleys **220**, **222**, as best seen in FIGS. **2**, **8–9**, for receiving each respective belt **204**, **208**, with a radially extending baffle **218** disposed between the pulleys so that the inwardly disposed stretch belt **204** is insulated from the wet environment in which the outwardly disposed timing belt **208** operates to drive the agitation brush **206**. A barrier coplanar with the radial baffle **218** insulates the environments from each other as formed by the juncture of a pair of belt access doors **250**, **252**, as will be described below. The stretch belt **204** also functions as a clutch when the agitation brush **206** is jammed. Because the agitation brush **206** is connected to the interim pump drive shaft, and the interim pump drive shaft **200** is connected to the motor drive shaft **198**, there must be some mechanism to provide relief to the motor **196** when the agitation brush **206** is jammed. This relief occurs at the drive shaft **198**, which will turn inside the stretch belt **204** without rotating the stretch belt **204** when the interim pump shaft **200** stalls due to an agitation brush **206** jam.

As best shown in FIGS. **5–9**, the timing belt **208** is structurally walled off from the stretch belt **204** by the barrier defined in part by the first belt access door **250**, second access door **252**, and the baffle **218**. Removing the first belt access door **250** provides access to the timing belt **208** connecting the pump drive shaft **202** and the agitation brush **206**. Access to the stretch belt **204** connecting the motor drive shaft **198** to the pump drive shaft **202** is provided only when the second belt access door **252**, disposed within a brush housing **26**, is removed. As illustrated in FIG. **2**, the first belt access door **250**, having a substantially L-shaped cross-section, includes a substantially vertical portion **266** and an angular, but substantially horizontal portion **264**. As best shown in FIG. **9**, the second belt access door **252** is rectangular, including an arcuate groove **254** in a front portion of a top surface **256** and a transversely extending arm **258** in a rear portion of the top surface. The arm **258** secures the second door **252** in place in the brush housing **26** and supports the pivot pin **462** on the pivot arm **460** of the floating brush assembly, as best shown in FIG. **5A**.

More specifically, as shown in FIG. **2**, the substantially vertical portion **266** of the first door **250** includes sides **240** that are received in a mated recess **242** surrounding an access aperture **236**. Further, the first door **250** includes a depending flange **234** mounted to and spaced apart from a back portion of the door **250** and extending downwardly parallel to the door **250** and further including an arcuate groove **244** in a lower end. Each side of the substantially horizontal portion **264** includes a flexible tab **226** on each side that is received in a respective slot **228** disposed on the substantially horizontal face **222** of the upper housing **17** at each end of the access aperture **236** that receives the first belt access door **250**. Thus, as the first belt access door **250** is slid into place, the depending flange **234** extends behind the upper housing **17** defining the access aperture **236**, the sides are received in grooves **242** in the upper housing **17** surrounding access aperture **236**, and the tabs **226** engage the slots **228** formed on the substantially horizontal portion **248** of the housing, whereby the first access door **250** is secured in place. The first access door **250** can be removed from the aperture **236** by flexing the tabs **226** inwardly to release them from their receiving slots **228**. As shown in FIG. **9**, the inner depending flange **234**, including groove **244**, mates with the radially extending baffle **218** between the pulleys **220**, **222** on the shaft **200** and the arcuate groove **254** in the arm **258** of the second belt access door **252** to separate the motor/pump stretch belt **204** from the pump/agitator timing belt **208**.

The pump priming system **280** is disposed adjacent the pump inlet nose **288**, and draws from the fluid supply chamber **49** and the detergent tank **870**. The fluid supply chamber **49** is under negative pressure because it is in fluid communication with the recovery chamber **48** and the vacuum source. Once primed, the pump **202** draws solution from the mixing valve assembly **310**, and delivers the

mixture to a spray tip 100 or an accessory tool 44 for spraying on the surface to be cleaned. When the pump 202 stops, the solution in the supply conduit is drawn into the low-pressure fluid supply chamber 49 and away from the pump 202. A centrifugal pump is incapable of developing sufficient pressure to prime itself by overcoming the negative tank pressure.

With reference to FIG. 7, a pump priming assembly 280 as described herein overcomes this problem. The pump-priming assembly 280, includes a priming chamber 260 for flooding the inlet nose 288 of the pump 202, an inlet port 282 for the chamber 260 that is fluidly connected to the nose 288 of the pump 202, and a pump outlet port 283. A vacuum port 284 is fluidly connected to the vacuum source 40, or a portion of the recovery chamber 48 that is in fluid communication with the vacuum source 40.

The pump-priming assembly 280 also includes a hollow valve body 298 having a plunger chamber 286 and a valve chamber 292. A valved opening 295 joins the valve chamber 292 and the priming chamber 260. An outlet opening 291 joins the valve chamber 292 and the plunger chamber 286. Also, an aperture 294 is formed at an upper inside portion of the valve body 298 to fluidly connect the valve body 298 and the outlet 284. An elongate buoyant plunger 290 having a top portion 297 at one end and a rubber umbrella valve 296 at the other is received for reciprocal movement inside the valve body 298. More specifically, the umbrella valve 296 reciprocates between the valved opening 295 and the outlet opening 291 and within the valve chamber 292. Thus, the plunger chamber 286 substantially houses the elongate plunger 290, while the valve chamber 292 houses the umbrella valve 296, which is coaxially attached to the elongate plunger 290 for reciprocal axial movement therewith.

In operation, the pump 202 will be primed with fluid from the fluid supply chamber 49 by activating the pump 202 and the vacuum motor 196, which will exert negative pressure on the vacuum outlet 284, thereby drawing any air out of the priming chamber 260 and plunger chamber 286, and further overcoming the negative pressure exerted on the fluid in the conduits 140, 142 connecting the fluid supply chamber 49 to the pump 202. The air will be drawn through the valve body 298 into the vacuum impeller fan housing 510. Preferably, the weight and dimension of the plunger 290 is coordinated with the amount of negative air pressure applied to the pump priming assembly 280 from the vacuum source 40 so that the negative air pressure applied to the plunger chamber 286 is insufficient by itself to draw the plunger 290 upwardly and seal the outlet opening 291

As the vacuum motor operates to draw the air from the system, fluid fills the chamber 260 and enters the chambers 292, 286. Eventually, the fluid level will fill the valve chamber 292 and rise inside the plunger chamber 286, pushing the plunger 290 upwardly causing the umbrella valve 296 to seal the outlet opening 291, thereby preventing water from rising further in the plunger chamber 286 and being sucked into the vacuum source 40. Because the pump nose 288 is submersed at this point, water enters the pump 202 and primes it. As the pump 202 sucks water from the priming chamber 260, the plunger 290 is drawn downward in the plunger chamber 286, and the umbrella valve 296 descends therewith in the valve chamber 292 to activate a seal in the opposite direction, as the umbrella valve 296 seats in the valved opening 295. The reverse seal prevents air from being sucked into the priming chamber 260 from the fluidly connected chambers 292, 286. This cycle repeats each time a trigger 432 in the closed loop handle 18 is activated or the unit is powered off and on again. Once the reverse seal has been established, the chamber 260 should remain filled, the nose 288 of the pump 202 flooded, and, thus, the pump 202 sufficiently primed for normal operation.

From the pump 202, the pressurized fluid flows through a conduit 146 to a T-connector 150 for supplying both floor nozzles 100 and an accessory tool 44. The T-connector 150 includes outlets 152, 154 for supplying both the in-line block heater 54, and a floor spray nozzle 64, or an accessory cleaning tool 44, respectively. Specifically, the first outlet 152 of the T-connector 150 is connected to fluid conduit 148 that is adapted to supply non-heated and pressurized cleaning solution to a spray nozzle (not shown) on an accessory cleaning tool (not shown) mounted at the terminal end of the accessory hose 22. The second outlet 154 is fluidly connected via a conduit 138 to the in-line block beater 54, shown best in FIG. 18.

The in-line block heater 54 receives pressurized cleaning solution from the pump 202, via the T-connector 150, and further has a heating element 56 that is electrically connected to a source of electricity (not shown). As shown in FIG. 18, the heater 54 includes an aluminum body 84 having an inlet port 72, an outlet port 74, a heating element 56 disposed within the aluminum body 84, and a serpentine channel 78 disposed on a top face 76 of the block heater 54. A cover 79, via a gasket 70 seals the top face 76, and thus the channel 78, and fasteners 86. The heating elements 56 located in the aluminum body 84 of the block heater 54 uniformly heat the fluid as it passes through the channel 78 across the block heater 54. The channel 78 includes an outlet port 74 through which heated fluid exits the channel 78 to the conduit 136. The heater 54 is mounted within the handle assembly 16 via shafts 71 and plugs 73 to bosses (not shown) in the handle assembly 16.

The size of the aluminum body 84 and the heating elements 56 are selected to effectively deliver approximately 500 watts of power to the heating block 54 to heat the cleaning fluid in the serpentine channel 78 to a temperature of about 150–180° during the dry cycle of the cleaner and apply that heated cleaning fluid during the wet cycle, as will be described more completely below. Use of approximately 500 watts of power for the heater 54 leaves sufficient power from a convention 120 volt power line for the vacuum motor, agitation brush and pump while beating the solution to the target temperature with a minimal warm-up time of approximately one minute. To enhance this process, hot lap water (defined as approximately 110–120° Fahrenheit) can be dispensed into the reservoir from a household tap. The solution that passes through the in-line block heater 54 is heated approximately 30° to 35° to reach a target temperature of approximately 150° Fahrenheit. A thermostatic controller is preferably mounted to a face of the heater 54 to limit the block temperature to 180° F. The solution that passes to the upholstery attachments does not get the temperature boost. A non-heated solution is preferred for upholstery, which is more sensitive to heat damage.

Powered by approximately 500 watts, the in-line block heater 54 will boost the temperature of water 16° Fahrenheit on a continuous basis at 850 milliliters a minute. Since an approximately 30° temperature increase is desired, it is necessary to store heat energy in the aluminum body 84 of the in-line heater block 54 during the dry cycle and deliver it to the solution during the wet cycle. The recommended cleaning process with the extraction cleaning machine 12 described herein is two wet strokes, defined as movement of the extraction cleaning machine 12 while cleaning solution is sprayed from the nozzles 100 to the carpet being cleaned,

followed by two dry strokes, defined as cleaning solution and dirt removal through the suction action of the suction nozzle **34**. There is thus an opportunity to effectively deliver 1000 watts of heat energy to the solution by storing 500 watts during the dry cycle. Furthermore, a typical cleaning stroke is about 10 seconds maximum, so the heat reservoir must have the capacity to store 500 watts for approximately 20 seconds, which equals approximately 10,000 Joules of energy.

The heating element **56** is embedded into the aluminum body **84**, which is of ample mass to store the energy at some temperature below the boiling point of water (212° Fahrenheit). The larger the mass of aluminum, the smaller the differential temperature needs to be to store the required energy. On the other hand, the larger the mass, the longer the initial heat-up period becomes. Thus, there is an optimal size of aluminum block that is calculated based on a thermostat shut-off point of 180° Fahrenheit. This block temperature keeps stagnant water from boiling and also heats the solution that passes through the serpentine channels **78** on the block face **76** to a temperature of approximately 150° Fahrenheit before leaving the in-line block heater **54** through outlet port **74**.

In operation, when the heater **54** is initially energized electrically, it heats to its thermostatically controlled shut-off temperature in approximately one minute. A thermostat **92** is included on a lower face **108** of the body **84**. During use, the cleaning solution passes through the heating channel **78** in the in-line block heater **54**, drawing energy from the aluminum body **84** and from the heating element **56** embedded therein adjacent the underside of the solution channel **78**. The aluminum body **84** cools somewhat during the 20 second cycle and reaches a temperature slightly below its starting temperature. During the dry cycle, the aluminum body **84** is reheated to its previous temperature of approximately 180° Fahrenheit. The heated solution leaving the in-line block heater **54** is applied to the carpet after passing through the conduit **136** to the flow indicator **650**, and the conduit **134** from the indicator **650** to the fluid dispensing nozzles **100**, which are positioned between the agitation brush **206** and the suction nozzle **34**.

The flow indicator **650** is placed in the fluid flow path to provide a visible indication of fluid flow to the fluid dispensing nozzles **100**. As shown in FIGS. **19** and **20**, the flow indicator **650** is mounted to an upper end of the arm **651**, which extends upwardly from the motor housing **500** in the base module **14**. An opening **653** in the upper housing portion **17** receives the flow indicator **650** when that portion is mounted to the lower housing portion **15**. Alternatively, the flow indicator **650** can be mounted to the handle assembly **16** in a position to be easily viewed by the operator. The flow indicator **650** comprises a circular body **660** having an inlet **652**, outlet **654**, and a clear lid **662** having a threaded lip **670**. As seen in FIG. **20**, the indicator body **660** preferably houses an impeller **664** superjacent a screen filter **666**, both of which are superjacent the fluid inlet **652** and the fluid outlet **654**. The fluid inlet **652** is near the periphery of the body **660** and the outlet **654** is disposed centrally. The lid **662** has threads **670** on the outside of the body **660**.

The lid **662** is clear, preferably made from the transparent plastic, so that the user can see the fluid flowing into the indicator **650** and rotating the impeller **664**. Alternatively, one or more articles, such as a ball or disk can be mounted within the indicator body **660** and subjacent the lid **662**, whereby the operator can determine if there is fluid flow by movement of the article. Further, while a body **660** mounting an impeller **664** is the preferred flow indicator, other suitable indicators include a float ball, spring plunger, or gravity plunger.

A float ball-type flow indicator can include a flow conduit having a T-shaped portion having a transversely oriented tube extending from a cylindrical body defining the fluid flow path. A ball or other article can be mounted at the junction of the transverse tube and cylindrical body for reciprocation within the transverse tube. When fluid is flowing through the cylindrical body, the ball or article moves into the transversely oriented tube, whereupon it is visible to the operator and indicates proper fluid flow.

A spring plunger-type flow indicator can include a light spring to bias a ball, plunger, or other article in a housing having a window visible to the operator. With fluid flowing through the housing, the ball, plunger, or other article moves against the bias of the spring to become visible in the window, thereby indicating to the operator that fluid is flowing properly. Alternatively, the ball, plunger, or other article can always be partially visible, and include portions corresponding to proper fluid flow, such as green for proper fluid flow and red for no fluid flow, whereby fluid flow causing movement of the ball, plunger, or other article against the spring bias would change the portion of the ball, plunger, or other article visible to the operator through the window, thereby indicating proper fluid flow.

A gravity plunger-type flow indicator can include a housing having a ball or other article mounted on a ramp adjacent a window. As fluid flows through the housing, the ball or other article is forced up the ramp, whereby it is visible to the operator to indicate proper fluid flow. Alternatively, like that for the spring plunger, a portion of the ball or other article previously not visible through the window can be visible when fluid flows through the housing to indicate to the operator that fluid flow is proper.

After pressurized fluid leaves the in-line heater **54**, it enters the inlet **652** of the flow indicator **650** under pressure, such that it causes the impeller **664** to rotate in a clockwise direction as pictured in FIG. **20**. The fluid rotates the impeller **664** until it reaches the center of the body **660**, where it is forced through the screen filter **666** and outlet **654** by the continuous flow of pressurized fluid into the flow indicator body **660**.

The screen filter **666** prevents any debris from exiting the flow indicator **650**. Any debris trapped by the screen filter **666** remains visible to the operator through the lid **662**. The operator can simply clean the flow indicator **650** by removing the threaded lid **662** and lifting the screen filter **666** from within the body **660** for cleaning. The screen filter **666** preferably includes apertures defined by the screen of a diameter smaller than the diameter a passageway through the spray nozzle **64**. This is of particular importance if the spray nozzle is not easily serviceable by the operator or a service provider. Further, when using an in-line heater **54**, a screen filter **666** is a precaution against plugging the passageway through the spray nozzle **64** from scales forming in the heater **54**.

After the cleaning solution has been applied to the surface to be cleaned via the spray nozzle **64**, or multiple spray nozzles **64**, the used cleaning solution and entrapped dirt are removed from the surface being cleaned through the suction nozzle **34**, which opens into the first working air conduit **704** extending along the top of the base module **14** between the upper housing portion **17** and the transparent facing **19**, as best shown in FIGS. **2**, **12** and **13**. The first working air conduit **704** terminates at a junction **740** with the second working air conduit **706**, which is defined by passageway communicating the vacuum source **40** with the suction nozzle (not shown) on the distal end of the accessory hose

22. With this configuration, the drive motor **196** creates the vacuum source **40** that is applied to the surface being cleaned through either working air conduit **704**, **706**.

The terminal end of the accessory hose **22** is secured to a hose mounting **702** at a distal end of the accessory hose intake duct **540** partially defining the second working air conduit **706**, which extends, in a U-shape, to the junction **740** with the working air conduit **704**, as best seen in FIGS. **1** and **12**. A flapper valve **114** pivots at the junction **740**, disposed in the base module **14**, to alternatively close the first working air conduit **704**, between the suction nozzle **34** and the air/water separator lid **700**, and the second working air conduit **706** between the hose mounting **702** and the air/water separator lid **700**, as best shown in FIGS. **12** and **14**. The valve **114** seats on a gasket **113** about the junction **740**. When the user is cleaning floors, the flapper valve **114** is in position to direct all of the working air generated by the vacuum source **40** to the suction nozzle **34**. However, when the user desires to use the accessory hose **22**, the flapper valve **114** is pivoted to an accessory hose position, as shown in phantom lines in FIG. **12**. In this position, the flapper valve **114** seals the working air conduit **704** and connects the accessory hose **22** to the vacuum source **40**. Regardless of whether the machine is operating for on-the-floor cleaning or accessory hose cleaning, all of the dirt and water recovered are directed into the recovery chamber **48**.

An over-center diverter valve assembly **110** including a movable flapper valve **114** in the junction **740** between working air conduits **704**, **706**, and actuable by an actuator knob **180**, on the extraction cleaner housing controls the diversion between the conduits **704**, **706**. More specifically, the actuator knob **180** to flapper valve **114** linkage assembly, as shown best in FIGS. **12** and **13**, includes an arm **160** attached at an upper end to the flapper valve **114**, which includes a transversely extending support axle **162**, and at a lower end to a cup-shaped bearing **170** on the end of a piston **172**. The support axle **162** is mounted for rotation in the junction **740** between the working air conduits **704**, **706**, whereupon the valve can pivot between two extreme positions, as shown in FIG. **12**. At a lower end, the arm **160** ends in a transversely extending leg **164**, which moves relative the center of the actuator knob **180** depending on the position of the actuator knob **180** when turned by the user.

The actuator knob **180** includes a handle **184**, and a piston assembly **190** on a back face. The piston assembly **190** includes piston housing **176**, piston **172**, and a compression spring **174**. The piston **172** slides coaxially in the housing **176**, and is biased upwardly by the spring **174** mounted therein. Specifically, the spring **174** biases the piston **172** out of an opening **196** in a top portion of a tubular piston housing **176**.

When the actuator knob **180** is turned by the user, the lower leg **164** moves closer or farther from the knob rotation axis, thereby increasing or decreasing the distance between the lower leg **164** and the axis. As this distance increases, the spring-biased piston **172** forces the lower leg **164** upwardly. The arcuate path of the lower leg **164** as it travels over the center of the knob axis rotation imparts rotation to the flapper valve **114** about the fixed support axle **162**. The rotation is in response to the changed distance of the mounting of the piston assembly **190** from the actuator knob **180** rotation center. As it moves away from the center, the piston **172** expands at an angle relative to the support axle **162**. The lower leg **164** of the L-shaped arm **160** must rotate in the cupshaped bearing **170** at the end of the piston **172** because the axle **162** is fixed. Thus, the flapper valve **114** rotates in response to the angle of the joint between the expanded piston **172** and the lower leg **164** (not shown). Tabs formed on the back face of the knob **180** limit the rotation of the knob so as to effectively define two positions correlating to the open conduit **704**/closed conduit **706** position and the open conduit **706**/closed conduit **704** positions.

The diverter valve assembly **110** described above permits the upright extraction cleaner fluid dispensing mechanism to be used as a pre-spray applicator. That is, by diverting the suction to the accessory hose **22**, and applying solution through the fluid dispensing nozzles **100** adjacent the agitation brush **206**, the upright extraction cleaner **12** can be used to dispense fluid and agitate the carpet without having the applied solution immediately extracted from the carpet through the suction nozzle **34** adjacent the agitation brush **206** and fluid dispensing nozzles **100**. Thus, the fluid application system **950** remains operable regardless of the position of the flapper valve **114**.

As best seen in FIGS. **12–14**, **14A** and **14B**, the working air conduit **704** terminates at the junction **740** with the working air conduit **706**. The junction **740** connects the selected conduit **704**, **706** to a U-shaped inlet **780** to the air/water separator lid **700**, which is secured to the tank assembly **50** by the rotatable handle **790**. Thus, from the U-shaped inlet **780** to the air inlet **764**, the air path entering the lid **700**, as shown in FIG. **14**, is substantially horizontal.

From the tank air inlet **764**, the air/water/debris mixture is conducted into a center portion of a tank lid separation chamber **750**, where the cross sectional area is greater than the flow conduits **704**, **706**, junction **740**, and inlets **780**, **764** to slow down the velocity of the air stream for gravity separation of the air from the liquid, dirt and debris. Because the lid **700** is formed of a transparent plastic material, the user can easily observe the dirt and water passing up through the intermediate flow conduit and the fluid level inside the tank assembly **50**.

The substantially rectangular chamber **750** is defined by a transparent lower portion **752** substantially surrounded on all sides by a transparent side wall integral with the underside of the air/water separation lid **700**. The chamber **750** is further defined upwardly by a transparent face **756** of the lid **700**. The air inlet opening **764** is disposed adjacent an air outlet opening **776**. The underside of the face **756** further includes a circular downwardly extending shroud **770** adapted to surround in part the open flexible bladder filling spout **124**, which is retained by the baffle plate **800** and positioned adjacent the separation chamber **750**.

The working air flow enters the hollow interior of the separation chamber **750** via the air and water inlet **764** and passes horizontally beneath the transparent face **756** to a rear wall defining a first diverter baffle **755** at which it is redirected 180° forwardly through an opening **751** to a rectangular, extended outlet passage **757** formed in a lower, intermediately disposed portion of the bottom wall **752** at which it is again redirected 180° by a second diverter baffle **759** defined by a front wall disposed forward, transverse, and beneath the opening **751**. The air flow then exits the separation chamber **750** through an inlet outlet **760**, whose position is dictated by tank geometry, as the preferred position is a"dead spot" in tank air flow to maximize air/water separation. From here, the water is directed into the interior of the tank between the **750** and the baffle **800**, and away from the separation chamber **750** to the air exit **762**. It is significant that all air/water separation occurs above the baffle plate **800**, thus minimizing interference with the recovered water (i.e., no foaming) in the area disposed

below the baffle plate **800**. This characteristic is necessitated by the inclusion of a flexible bladder disposed in the tank recovery chamber.

In summary, air and water enters the inlet **764**, from where it is channeled to the air/water separation chamber **750** in which it strikes the first diverter baffle **755**, is redirected approximately **180°** and through the opening **751** to the outlet passage **757**, where it is again redirected approximately **1800** by second diverter baffle **759**, and then passes into the interior of the recovery chamber **48**. The multiple changes in direction as well as the expansion in volume in the separation chamber **750** facilitate the separation of water and debris from the air. As best seen in FIG. **14**, the air, free of water and debris, exits the tank via rectangular outlet **762**, and traverses a horizontal conduit **774** to a vertical exit conduit **776**, which is disposed adjacent the horizontal inlet **780** leading air into the separation lid **700** via air inlet opening **764**. Thus, the air inlet **780** and air exit conduit **776** are vertically adjacent. The air exit conduit **776** feeds the vacuum intake duct **530**, which is connected to the vacuum source **40**, as best seen in FIGS. **2** and **15**.

As best shown in FIGS. **3**, a fluid containment baffle **800** is mounted inside the hollow interior of the tank assembly **50** immediately below the separation lid **700**, and is intended to prevent the excessive sloshing of the recovered dirt and liquid and also contain any foam generated inside the tank assembly **50**. The planar baffle **800** comprises a flat body **810** mated to snap fit within the tank housing **46**. Further, apertures **820** are formed through the plate **800** for receiving the recovered fluid into the recovery chamber **48** of the tank assembly **50**. A circular aperture **826** retains the bladder filling spout **124** in position by preventing it from floating upwardly in the tank and further locking the bladder in place while giving it mechanical support.

The baffle plate **800** is snapped into place by retainers **830** that are received on tabs **836** formed on the interior of tank housing **46** to secure the baffle plate **800** in the tank assembly **50**. The apertures are centrally mounted in the baffle plate **800** to prevent air movement, while facilitating fluid and debris deposits, into a lower portion of tank assembly **50** so that the recovered fluid remains undisturbed. Further, the baffle plate **800** is closed at the edges to prevent sloshing of the recovered fluid into an upper portion of the tank assembly **50** during movement of the cleaning machine **12**.

As shown best in FIGS. **14** and **14A**, a float assembly **900** extends through the baffle plate **800** for moving an integral door across the exit port of the tank to prevent recovered solution from entering the tank exhaust in an overfill condition. As best shown in FIG. **3**, the flag-shaped float assembly **900** comprises a buoyant base **902** and a closure plate **904** interconnected to one another by a support plate **906**. The closure plate **904** is dimensioned to fully seal the air exit **762** to the tank to prevent recovered solution from entering the tank exhaust in an overfill condition as illustrated in phantom lines in FIG. **14A**. The closure plate **904** further includes a pair of triangular projections **905** extending transversely from a substantially vertical front face. The front face engages the wall **768** defining the air exit **762** from the tank, and the projections **905** cam along that wall **768** to prevent premature and partial closing of the exit **762** as the plate **904** is drawn against the exit by the suction therethrough.

The float assembly **900** is limited primarily to vertical movement with respect to the tank assembly **50**, with the closure plate **904** positioned above the fluid containment baffle **800** and the buoyant base **902** positioned below the baffle **800**. A narrow slot **920** is provided in a front portion of the baffle **800** through which the support plate **906** of the float extends. Further, a housing **910** secured to the interior of the tank housing **46** guides the buoyant base, and thus the float assembly **900**, in a vertical direction. In the assembled position, the closure plate **904** is positioned above the baffle **800** and the buoyant base **902** is positioned below the baffle **800**.

As the recovered fluid within the tank assembly **50** rises, the float assembly **900** will also rise until, eventually, the closure plate **904** nears the tank exhaust exit opening, at which point the closure plate **904** is sufficiently drawn against the exit **762** opening by the suction from the vacuum motor to close the airflow therethrough. As discussed above and illustrated in FIG. **14A**, the triangular projection **905** extending from the front face **907** ensure the closure plate is not drawn against the exit **762** prematurely, which would result in a partial closure of the opening. Rather, the projections **905** ride the housing defining the opening until drawn into total closure of the exit **762**. Once this happens, the pitch of the operating vacuum changes sufficiently to warn the user that the fluid recovery chamber **48** is full and must be emptied.

As best shown in FIG. **3**, a drain plug **850** seals an aperture through a wall in a lower portion of the rigid housing **46** of the tank assembly **50** through which recovered fluid can be removed without tipping the tank assembly **50**, and also through which the tank assembly **50** can be cleaned by flow-through rinsing. More specifically, a rounded wall of the rigid tank housing **46** includes the drain plug **850** mounted in an aperture **854**. A bottom portion of the aperture **854** is substantially planar with a bottom wall **860** of the tank housing **46**. Thus, any recovered fluid will flow through the aperture **854** when the drain plug **850** is removed therefrom. Further, the tank assembly **50** can be cleaned without having to tip the tank assembly **50** since the drain plug **850** can be removed for flow-through rinsing. This feature is particularly important because the flexible bladder **120** defining the fluid supply chamber **49** remains in place while the recovered fluid is drained from the recovery chamber **48**. The drain plug **850** eases cleaning of both the interior of the rigid housing **46** and the exterior of the flexible bladder **120**.

As best shown in FIGS. **21** and **22**, the drain plug **850** comprises a knob **851** extending through a circular washer **856** which mounts two resilient legs **853**. The resilient legs **853** are located diametrically on a lower face of the washer **856** and comprise, on an outer face of each leg **853**, an upper ridged protrusion **857** and a lower ridged protrusion **858**. The lower ridged protrusion **857** is rounded so that it forms a detent mechanism with the opening in the tank wall. The upper ridged protrusion **857** has a slanted outer surface so that the legs are resiliently deflected as the drain plug is installed into the aperture **854**, and has a sharp return inner surface so that the return inner surface will bear against the inner surface of the wall of the tank housing as the drain plug **850** is pulled outwardly of the tank. Thus, the drain plug is easily installed into the aperture **854**, but is retained therein by the inner surface when the plug is removed from the aperture **854** for draining the tank. In the normal, closed position of the drain plug **850**, the lower face of the washer **856** abuts the rear wall of the tank housing **46**. The drain plug further has a pair of retaining flanges **859** which fit behind the wall of the tank adjacent the aperture **854**. To this end the aperture has indented slots to receive the flanges **859**. The To drain fluid through the aperture **854**, the drain plug **850** is rotated a quarter turn counterclockwise and